

SRA | SOLDERING
PRODUCTS

How to Solder Electronics

15 Rules for Successful Soldering

SECOND EDITION



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A faint, light gray background pattern of a circuit board with various electronic components like resistors, capacitors, diodes, and integrated circuits.

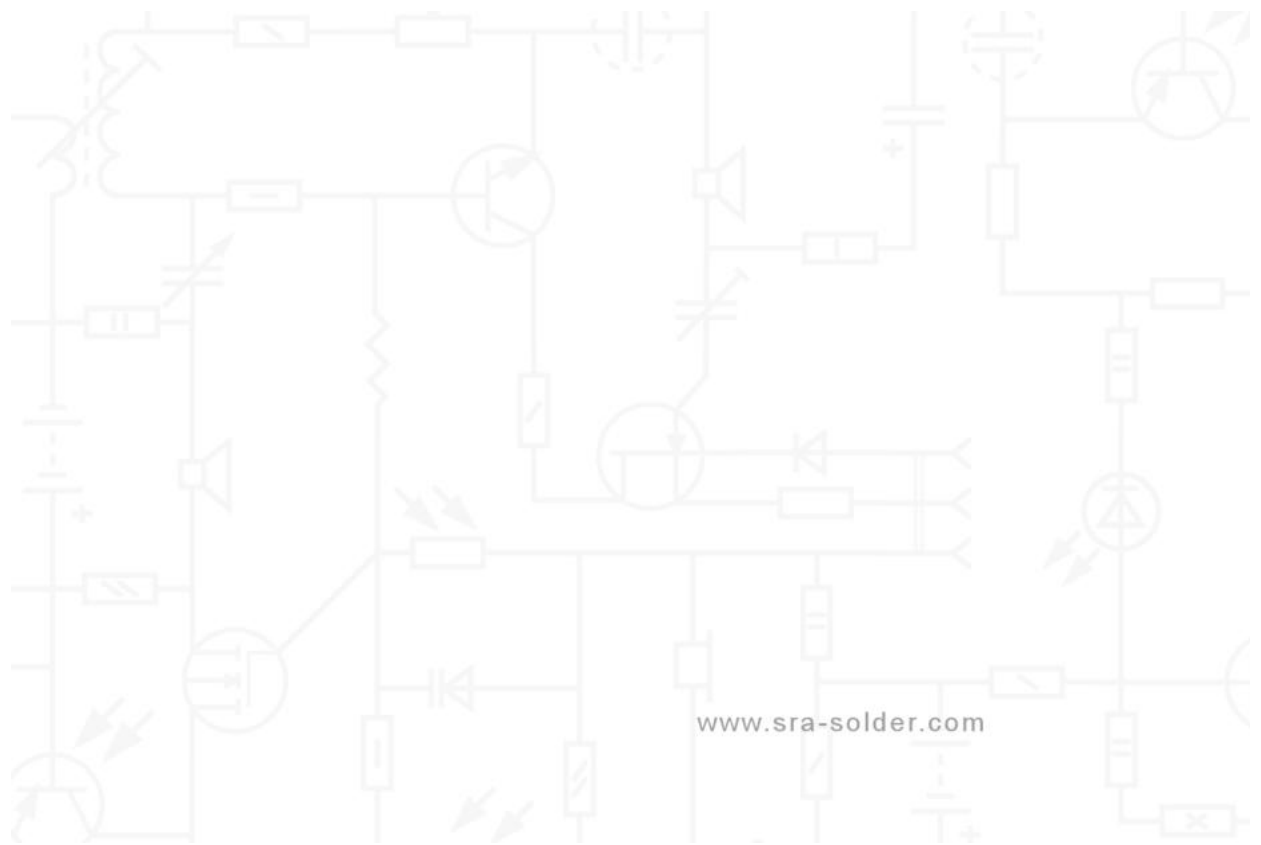
SRA | SOLDERING
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How to Solder Electronics

15 Rules for Successful Soldering

Written and published by

SRA Soldering Products



How to Solder Electronics: 15 Rules for Successful Solder

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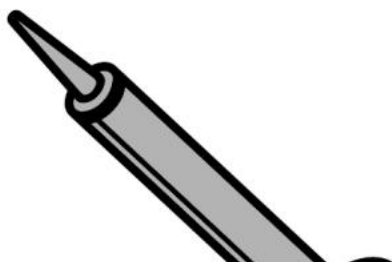
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Introduction

Here at SRA, we believe anyone can solder! After all, it's not hard to learn how to melt some solder and make an electrical connection. In our 60 years of providing soldering and brazing solutions, we've found that most solder problems are a lack of knowledge, experience, or the proper tools for the job. Our aim with this guide is to explain the science behind how soldering works, why various reactions occur, and how to produce a highly reliable connection with these factors in mind. Whether you're a beginner, experienced technician, or manufacturer this information should be added to your studies and skillset. If you're someone who struggles with soldering, understanding the "why" so you can improve. In order to make this guide easy to follow, we have broken it down into 15 rules that cover everything you need to know about our best techniques for soldering success!





Rule #1 – Know the Fundamentals

First things first, let's define what we're talking about here. Some people say 'solder', others say 'sodder'. It all depends on where you're from but believe it or not, it's the same thing! The term solder can be expressed as both a verb and a noun. 'to solder' describes the action of joining together two or more pieces of metal using soldering techniques. While solder the noun, refers to the so-called "glue" that joins the metals together.



What is Solder?

Solder can technically be described as a fusible metal alloy that is melted and flowed into a solder joint location where electronic components are joined (to form a mechanical and electrical connection).

The primary metal used to make solder is tin. It usually includes other metals and additives to enhance its physical properties. These special alloys (mixtures of metal) make it possible to melt the solder to a liquid and back very quickly, using a heat source such as a soldering iron. The most important thing to know about solder though is that it does not work without flux.

What is Flux?

Flux is a chemical agent that de-oxidizes the metals you're soldering. This provides a clean surface for the solder to adhere to. Flux is commonly found inside solder wire but also in liquid and paste forms. Earlier we described solder as "glue" but without flux or enough flux, the solder will not be able to bond properly in a process called wetting.



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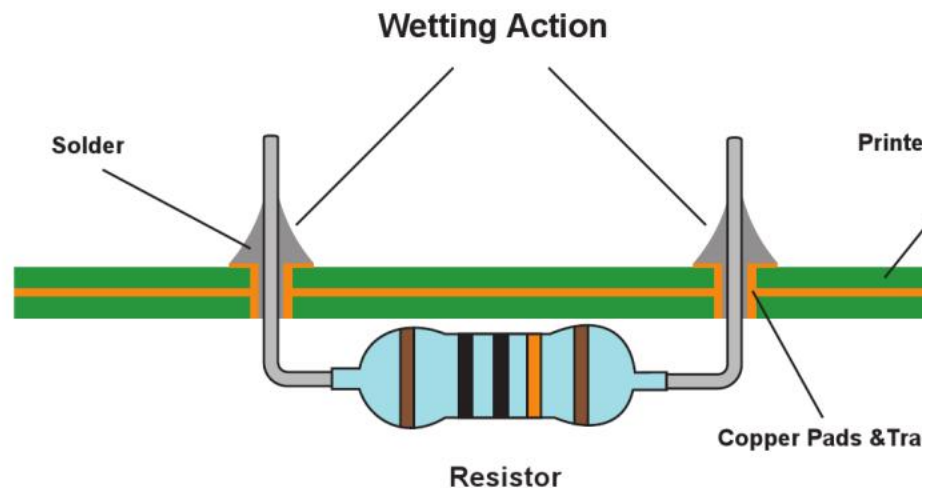
Rule #1 - Know the Fundamentals

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What is Wetting?

The term wetting is used to describe the characteristic of how quickly solder bonds to a given surface. Instead of simply covering like hot glue, the molten solder and plated copper on the board or electronic component bond together to form a new alloy that is mechanically stronger and electrically conductive throughout.

When proper wetting has occurred, the solder cannot be scrapped off after cooling. However, the bond can be undone through the process of desoldering; which involves re-melting the solder and removing the wire or component.



The ideal solder joint should appear smooth and cone-shaped with a 40-70 degree wetting angle.

Even when metal surfaces appear to be clean, there is an invisible layer of contamination that can prevent proper wetting.

builds up when exposed to air. These oxides are present not only on the surfaces but on the solder itself. If left as is, the solder will not be able to form a bond. A good flux will dissolve the surface oxidation and keep it clean enough for the solder to do its job.

What flux will not do is remove any visible dirt, oils and residues so a pre-clean may be necessary before soldering. We will cover cleaning methods in later sections. What you need to know right now is that flux can only be activated with heat!

2

Rule #1 - Know the Fundamentals

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Methods of Heat Transfer

Solder, flux, and heat make up the three essentials of soldering. Without j them, the process is not possible. There are also three distinct methods o when it comes to soldering, each of them using different tools to accompli



Conduction - Hand Soldering

This method typically uses a soldering source and will be the primary focus of A great deal of electronics soldering ca through conduction hand soldering.

Convection - Reflow Soldering

This method typically uses a hot air gun, specialized oven, or furnace as the primary heat source. Reflow is necessary for electronic components that are too small to solder with an iron. This method is sometimes referred to as “sweat soldering”, especially in the plumbing and jewelry industries.





Combination - Wave Soldering

This final method uses a wave soldering that combines conduction and convective heat source. It is an automated process manufacturing to solder devices quickly with a wave of molten solder.

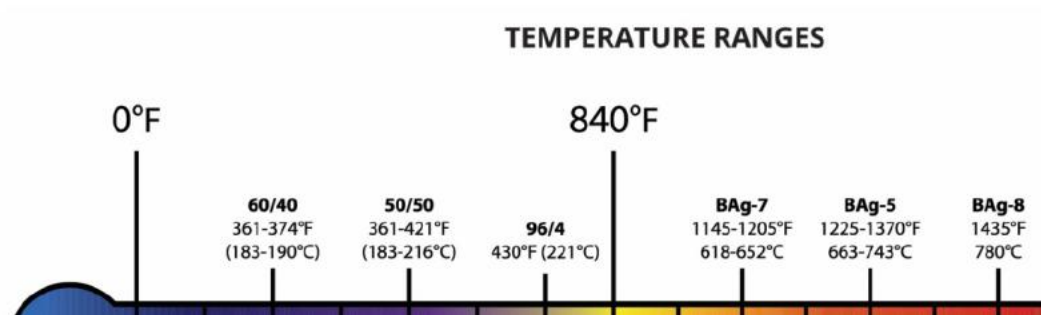
The Difference Between Soldering, Brazing, and Welding

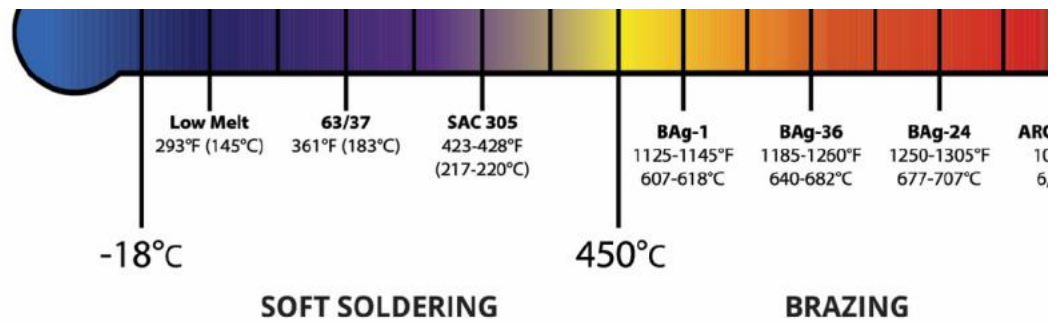
Soldering is not to be confused with the terms brazing or welding, which also describe the process of joining two or more metals. People will often use the terms interchangeably, very commonly referring to brazing as soldering. However, the three processes differ in three distinct ways.

Temperature Range

The main difference is the temperature range in which they occur. Solder melting temperatures below 840°F (450°C) are considered to be “soft” when soldering above that point is referred to as “hard soldering” or brazing; also called silver soldering when an alloy containing silver is used. Brazing is used in applications such as plumbing, jewelry, and dentistry. Whereas all electronics soldering is considered soft soldering.

As for welding, the process occurs much higher up on the scale at around 2500°F (1370°C) and up! The chart below shows where these processes occur along with the melting points for popular solder alloys used.





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Rule #1 - Know the Fundamentals

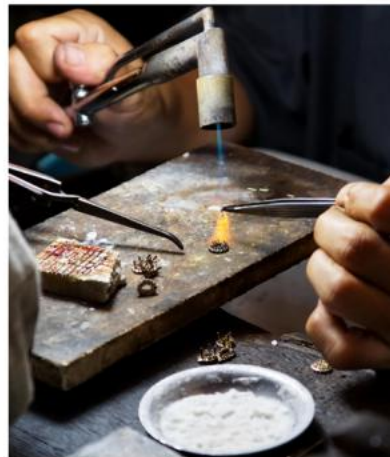
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Equipment Used

The second difference is the equipment required to reach each respective range. Since soft soldering occurs at a relatively low temperature, it can be done with just a soldering iron, hot air gun, or preheater. Whereas the higher temperature brazing requires a butane torch, acetylene torch, hydrogen torch, or furnace. The extremely high temperatures used for welding require a MIG, TIG or ARC welding process.



Soldering



Brazing



Welding

Joining Process

The final difference is the process by which the metals are joined. For soft soldering the process is the same. The solder alloy used has a lower melting point than the metal it is being applied to. In these reactions, the solder alloy is melted into the work pieces through solution or wetting action.

Welding is fundamentally different than soldering or brazing because the

welding is fundamentally different than soldering or brazing because the materials themselves are being melted and fused together; meaning it is not reversible. The original metal is still used in the process but the joint formed is actually stronger than the original base materials. Welding is common in metal fabrication, construction, and industrial manufacturing applications where the utmost strength is needed.

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Rule #1 - Know the Fundamentals

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When Do I Need to Solder?

At this point, you should be fairly confident in your knowledge of metal joining using solder and heat. But what about the increasing number of solderless components are out there? We assume you're reading to learn how to solder but we both have distinct advantages and disadvantages to both, as well as certain times to use each. We also think an explanation will help you understand the benefits of soldering and when to use it!

Solderless Advantages

- ✓ Minimal Investment in equipment and parts
- ✓ Ease of use, very simple to make a connection
- ✓ Convenient to disconnect if you need to change or repair something

Solderless Disadvantages

- ✗ Purely a mechanical connection, reliant on tension only
- ✗ Exposure to air and condensation will cause oxidation over time
- ✗ Movement and vibration will loosen the connection over time. Every

solderless cable is plugged or unplugged, the integrity weakens

- ☒ Nuts & bolts or set screws can only be tightened so much before bre connecting wires

Soldered Advantages

- ✓ Proper soldering creates a permanent connection that is air-tight. Since the joint becomes encapsulated in solder, the risk of oxidation is diminished.
- ✓ Soldering creates a very strong electrical connection and superior contact between the parts.
- ✓ The resulting connection is highly reliable under most conditions including vibration. Soldered connections can take a lot more abuse than solderless.

Soldered Disadvantages

- ✗ Greater investment in equipment needed to produce a proper soldered connection.
- ✗ Takes some time to learn the skill and solder proficiently.

In our opinion, solderless solutions are best used in instances where high reliability is a requirement. Components that will exist only in low stress conditions or be changed in the near future are the best candidates. Also, in areas where repair is not as feasible such as electrical receptacles or in vehicles.

We do recommend solderless connections for prototyping and testing but when time to construct a finished product, soldering is necessary. Likewise, any connections that need to withstand a lot of abuse and last a long time should be soldered. Wires and cables that will be plugged and unplugged frequently.



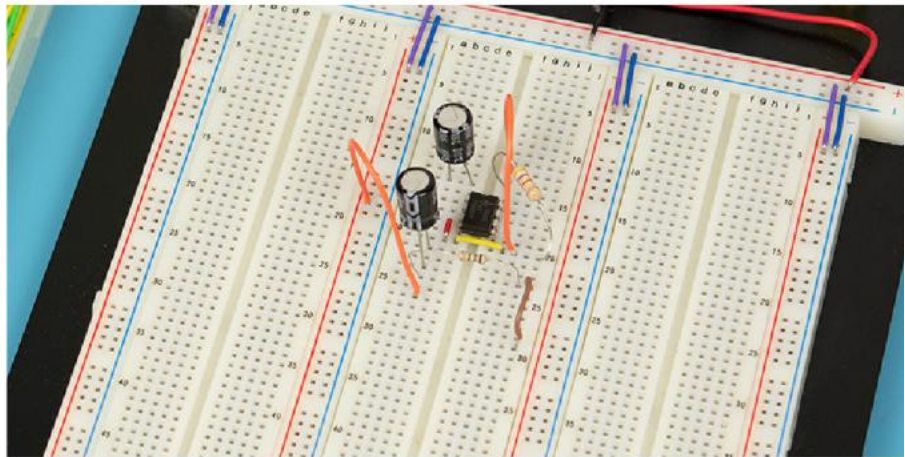
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Rule #1 - Know the Fundamentals

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Rule #2 – Identify the Construction Method

There are many ways to build a circuit using both soldered and solderless circuits are comprised of a collection of electronic components that come form an electronic device. Getting to know each type of component and th important to designing and building a circuit. This guide won't address circ it will consider the different types of construction you may come across.



Breadboards and Learning Labs

When first conceptualizing a circuit, you may want to produce a prototype. This can be done quickly on a breadboard, which is a solderless prototyping board with little holes for component leads that are electrically connected by internal

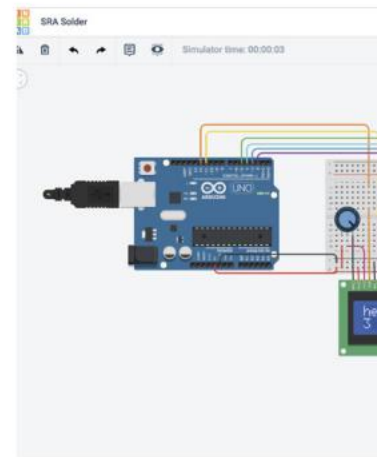
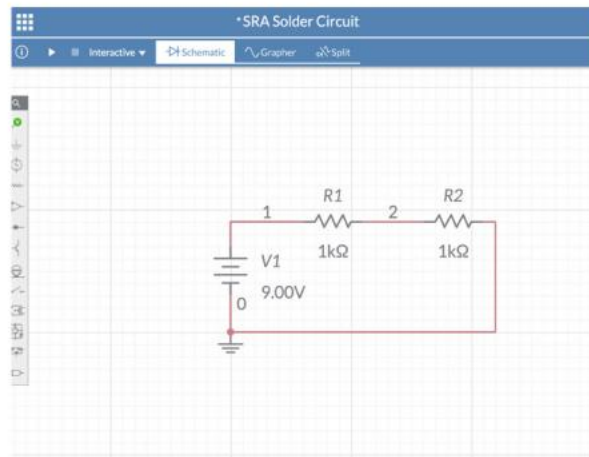
There are also electronic learning boards available that include a breadboard and other components such as potentiometers, connectors, and even a speaker, completing a variety of projects. Some technicians prefer to build their own devices with their favorite and most used parts to aid in creating new circuits.



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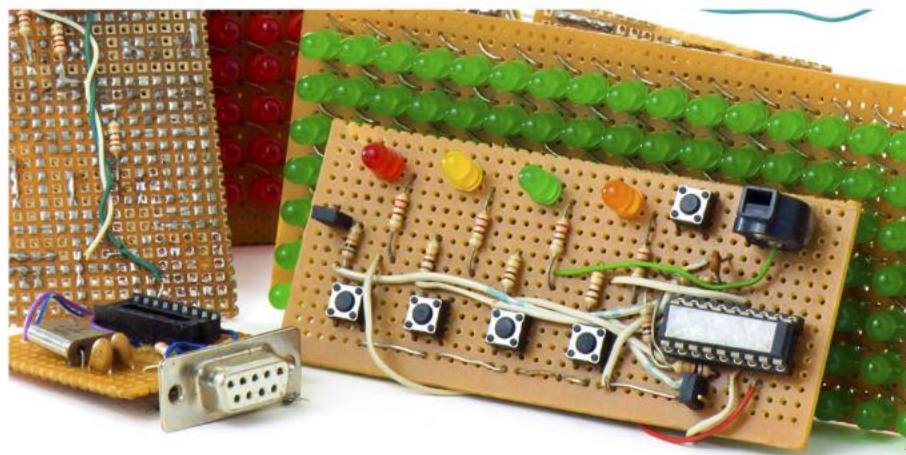
Rule #2 - Identify the Construction Method

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Computer Simulations

Alternatively, you could use computer simulation software like Multisim LI or TinkerCAD to design and layout your circuit. Multisim is better suited for circuit schematics while TinkerCAD is more visual layout based. It's also great if you have parts on hand or want an idea of the outcome before building. TinkerCAD has a drag-and-drop components for Arduino builds!



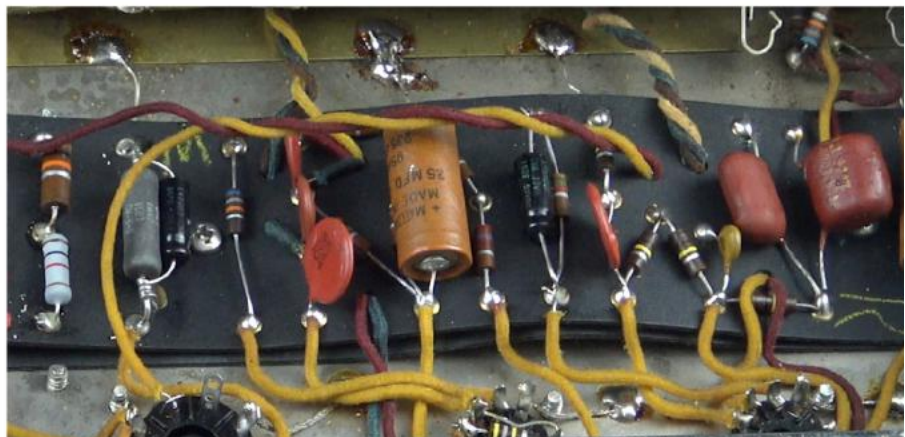
Protoboard, Perfboard, and Stripboard

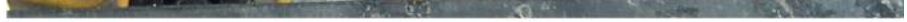
There comes a time where you'll want to test your circuits under real-life conditions by creating a soldered prototype. Protoboard or perfboard is perfect for this task. Protoboard has lots of holes with pads on which to solder. Stripboard is similar, except the pads are connected to each other by copper strips. The holes are very closely spaced on both, allowing you to create solder paths by bridging them with solder. Both offer many layout options. Ease of use makes these great options for prototyping and practicing your soldering skills!



Point-to-Point

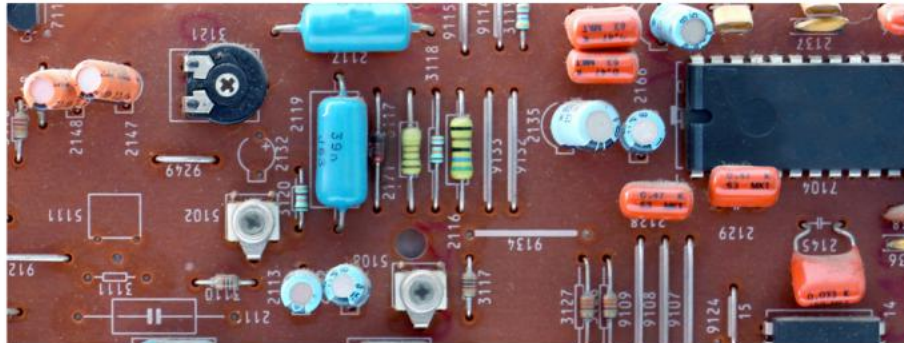
Once upon a time before circuit boards, electronics devices were constructed with component leads soldered directly to each other. Connecting components this way means there is less distance between them and therefore less resistance. Since the signal does not have to travel as far, it results in the cleanest and shortest signal path possible. For this reason, some Hi-Fi audio equipment and amplifiers are still built using point-to-point style wiring. The major downside of this method is the very limited layout options that make for a complex, "rat's nest" looking circuit.





Tag Board, Turret Board, Eyelet Board

In response to this layout issue, engineers came up with terminal strip construction which is just an intermediate form of point-to-point. Instead of direct connections, components are laced through or around metal terminals that come on either side of the boards. Everything is then connected up with wires to where they need to go. This makes component layouts more uniform and decreases production time. Terminal strip construction is very solid and allows more options than true



Through-Hole Technology (THT)

The increased use of transistors and advent of integrated circuits (IC chips) created the need to fit more and more components into less and less space. The solution was the printed circuit board or PCB, invented in 1943. These custom boards allowed engineers to more creatively arrange their components and link them through pathways (traces) embedded in the insulated layers of the board. The boards had pre-drilled holes for component leads with plated pads or "lands" on the board. These components are called through-hole devices (THD). Sometimes the holes are plated all the way through, which is referred to as plated through-hole (PTH).



Surface-Mount Technology (SMT)

The culmination of all these electronic construction advancements brings surface mount technology. SMT further improves on the space saving qualities of through-hole by allowing components to be directly soldered to the surface of the PCB instead of through it. This means engineers could now populate the top and bottom, effectively doubling the capacity of the board. Since SMD components are also significantly smaller than through-hole, devices could be built much smaller. The downside is that they are harder to go, the more difficult it becomes to service and repair. A lot can be done with a soldering iron, but some really small package sizes require more advanced techniques to be done right.

Rule #3 – Choose the Right Solder and Flux

When starting any soldering project, the right combination of solder and flux is essential. Solder comes in a variety of forms for use with many different types of heating methods. Below is a brief overview of some of the different forms you may come across for electronics work with a soldering iron, you are always going to use flux.

Forms of Solder

Solder Wire



The most common form of solder. Comes on a spool with or without a flux core.

Solder Paste



A mixture of solder and flux that usually comes in a syringe for precise application to small surface-mount components.

Solder Bars



Simply a bar of solid solder used for high production work. It can be melted into a solder pot for dipping or used in wave soldering.

Solder Preforms





Preforms come in a variety of shapes and sizes such as discs, and sheets. They are usually custom and the price varies according to the amounts for repeatability.

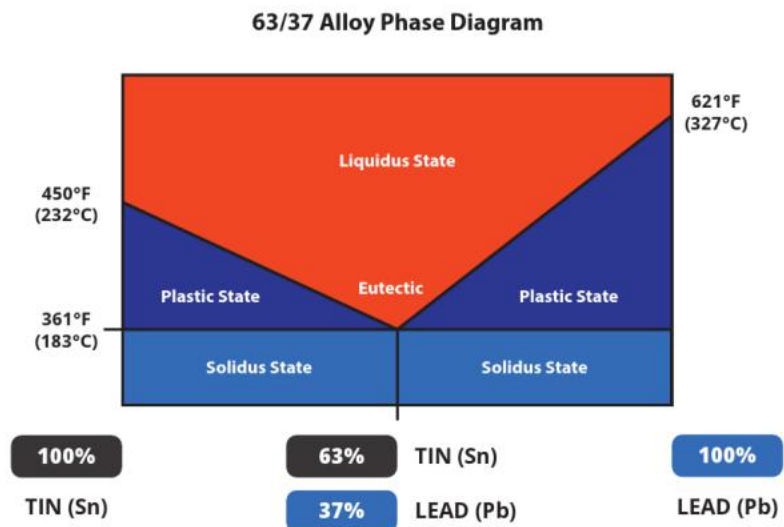


Solder Spheres

Also called solder balls, these tiny spheres of solder are used for soldering BGA type chips using a template.

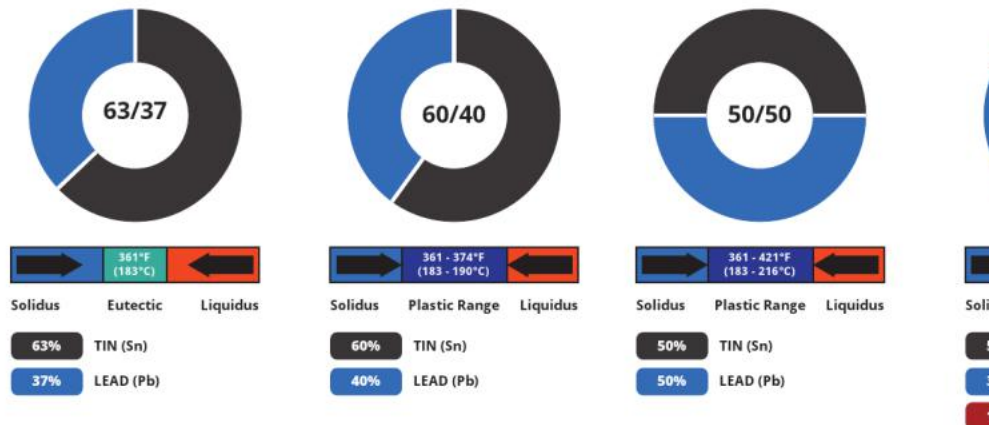
Leaded Solder Alloys

Traditional solder has always been made of tin (Sn) and lead (Pb) in varying proportions. The most common alloys being 60/40 (60% Tin / 40% lead) and 63/37 (63% Tin / 37% Lead). These particular metals were originally chosen for their low melting point when combined and superior wetting abilities.



When melting solder, it must reach a completely liquid state for proper wetting. The state between solid and liquid is known as the plastic state and if the solder gets hot enough to leave this partially melted state, it will result in a poor connection. There are special alloys like 63/37 that melt and solidify at the same temperature. These so-called Eutectic alloys are much easier to work with because they do not have a plastic state. For this reason, we usually recommend 63/37 for electronics work. While 60/40 will yield a shinier joint but you must pay closer attention to ensure proper

POPULAR LEADED SOLDER ALLOYS



Lead-Free Solder Alloys

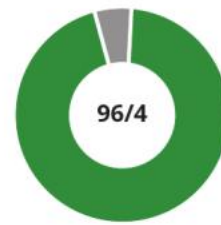
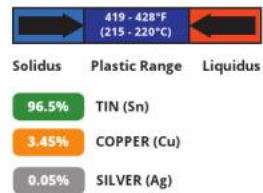
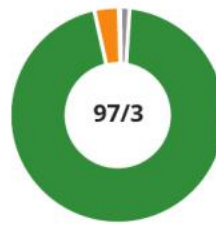
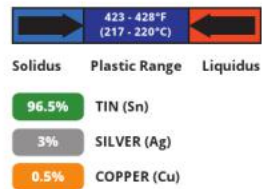
In recent years, the world has become more cognizant of the dangers of lead. In response to this, many governments have implemented lead-free initiatives to help limit exposure. Some regions have gone so far as to ban the sale of leaded alloys to non-commercial consumers. Most modern consumer electronic devices are now constructed with lead-free solder. However, hobbyists and repair shops continue to use leaded varieties for two very good reasons:

1. Leaded solder is easier to work with because of its low melting point and good wetting properties. Lead-free alloys can't quite match the performance and require higher temperatures to make a proper connection.
2. It is a general rule of soldering to match the solder and flux chemistries. For example, hobbyists and repair shops reworking vintage equipment like vacuum tubes should not be using lead-free alloys because the devices were not built with them in mind.

That being said, lead-free alloys have come a long way since their inception. Modern lead-free alloys produce good results as well. The most popular lead-free alloys in our experience are SAC305 (96.5% Tin / 3% Silver / 0.5% Copper) and 96/4 (96.5% tin / 3.5% Silver / 0.5% Copper). For most electronic lead-free soldering, we recommend SAC305 because it outperforms others in wetting ability. In the end, the lead versus lead-free decision is ultimately up to you, but definitely remember to avoid mixing alloys and flux chemistries for the best results.



POPULAR LEAD-FREE SOLDER ALLOYS



Solder Wire Gauge

Once an alloy has been chosen, the next consideration to make is the gauge of the solder wire. For general soldering, a wire gauge of 0.31" is a good size. For very large connections with more surface area, something like 0.62" is very suitable. Finally, for smaller surface-mount work, around 0.20" gauge would be appropriate to avoid flooding the joint with too much solder.

AWG	inches	mm
● 26	0.015"	0.38mm
● 24	0.020"	0.51 mm
● 22	0.025"	0.64 mm
● 20	0.031"	0.79 mm
● 18	0.040"	1.02 mm
● 17	0.047"	1.19 mm
● 16	0.050"	1.27 mm
● 14	0.062"	1.57 mm
● 8	0.125"	3.18 mm

It's important to note that as wires get larger, the flux-core can become more inclined to flow out during manufacturing and additional flux may be needed. This can be achieved by using an additional applied flux paste or a liquid flux in the joint.

Many technicians prefer using additional flux every time to ensure the highest quality connection possible. A common use is to be using rosin flux paste to coat wires before soldering. By dipping the entire solder wire in flux, you can be certain the solder will flow and wet exactly where you need it. It will always follow the path of least resistance, even when uphill. The flux effective path as long as the joint is clean and free of oxidation.

Solder Spool Size

The final consideration to make when choosing solder is the spool size. Solder is most commonly found in 1- or 1/2-pound spools which will last many a year. Think about how much soldering you intend to do, and decide accordingly. Also, 1, 2 and 4-ounce spools are available which are great for smaller projects or for driving different solder and flux combinations.



Choosing a Flux

When choosing a flux, the main consideration is the type of metal that you to solder. Not all metals are solderable or capable of wetting and certain r aluminum and stainless steel require specialized fluxes. In the electronics not as much of a worry because the fluxes are specifically formulated for What's more important in this case is the aggressiveness of the flux and t following are the common forms of flux you will come across.



Flux-Core Solder Wire

The easiest method of applying flux is through flux wire. As the name implies, there is one or more c present throughout the length of the solder wire. I so that when you melt the solder, the perfect pre- amount of flux is also applied. The percentage of typically between 1-3% and will usually be printed The higher the flux content, the more active it will oxides.

If flux-cored solder wire doesn't seem to be doing the job. This is usually l leads on the component or the pads on the board are too badly oxidized. the wire is not up to the job and a separate flux should be added. If you're core, make sure to match the separate flux to it. For example, if using a s a No-Clean flux core, choose a No-Clean Flux as your separate flux. If yo Rosin-core flux, then use a Rosin Flux. When using a separate flux, it ger use a solid solder wire together with the flux, to avoid combining two fluxe at cross purposes.



Flux Paste

Flux paste can be used in addition to solder wire for better performance and make soldering easier. It can be applied for applying with a brush or firm like our #135 Rosein for dipping wires. Use a toothpick or similar tool to apply where you want it and in the quantity that you need.



Liquid Flux

Liquid flux is great for applying precisely to your solder joints. It can be applied with a cotton swab, pipette, fine brush, or even a fluid dispenser.



Flux Pens

Flux pens are a simple and convenient way to apply flux. The flux is saturated at the felt tip and it allows you to apply flux exactly where you need it.

Now that we've discussed some forms flux comes in, let's move on to the factors that define their aggressiveness. There are two main categories of flux, organic and inorganic. Organic fluxes are used for electronics whereas inorganic fluxes are more corrosive and used for industrial applications.

Inorganic fluxes are usually acid-based and should **NEVER** be used on electronics. While it's true that all flux is acidic to an extent, anything containing zinc-chloride, a common plumbing flux found at hardware stores will eat away at electronic components.

No-Clean Flux



The least active type of flux to use. In order to be considered No-Clean, the flux must be able to be removed from the circuit board without cleaning and the components must not be harmed by the flux.



this flux when the PCB and/or leads are re and not very oxidized.

Tacky Flux



Tacky fluxes come in paste form and are u by a syringe. You can easily apply more fl could with a liquid form.



Rosin Flux

The most common organic flux is Rosin which is a pine tree resin. You may have seen solid Rosin for bows but with some additions, Rosin can become flux. There are three types of Rosin based on their

R - Non-Activated Rosin

Non-activated rosin flux is for soldering copper and it is the least active of the three. For solderable surfaces must be considerably clean for it to work effectively but it is non-corrosive and non-conductive.

RMA - Rosin Mildly Activated

As the name suggests, type RMA does include additional activators that help to clean and deoxidize.

These fluxes contain a small amount of additional activator to enhance cleaning and deoxidation leaving only a minimum amount of inert residue behind. All RMA fluxes are characterized by their non-conductive residues and high degree of freedom from contamination after cleaning.

RA - Rosin Activated

Type RA are most active of the rosin fluxes, and leave the most residue, but they are also the most

residues can be removed with appropriate flux cleaners. These 3 fluxes (1 are the only ones specified for Military Specification (Mil-Spec) application

Rosin and no-clean are both great choices that do not need to be cleaned soldering. Rosin fluxes will leave an amber residue but it is non-conductive has some protective qualities for the surface of the parts and board.

They are known to be reliable and usually more active than No-Cleans. The higher the flux the ability to withstand higher and prolonged heat than No-Clean Flux residue has a hard coating, which can “lock in” corrosive activators once the work is done.

Some Rosin Fluxes (Type R and some Type RMA) are actually certified “No-Clean” fluxes, but many Rosin Fluxes are NOT No-Clean fluxes. Many users assume all Rosin Fluxes are No-Cleans, which is not the case. Type RA fluxes would require additional tests required to designate a flux as a “No-Clean.” Sometimes people treat all Rosin fluxes as No-Cleans, but if a flux is not certified as a “No-Clean”, then you have a chance the flux residues, if left on the board, will cause corrosion. Sure, you can encase potentially corrosive elements in the flux residue, but if the flux is not certified as a “No-Clean,” then it is recommended that flux residues be removed after assembly.

RA Flux residues can be cleaned with Mineral Spirits or Isopropyl Alcohol. You may have to use a Q-Tip to remove all the residues, but they'll come off.

Water Soluble Flux



This type of flux is best reserved for when and Rosin fluxes are not strong enough to. The flux residues can be removed with water, which is much friendlier than alcohol solvents. The downside is that it must be washed off which adds more steps to the soldering process.

Most people will see water soluble as an advantage and think it's less harsh on the environment. The truth is that it is actually more aggressive and yes the flux residue washes off but you have to wash them off. It is an extra step over other no-clean fluxes.

leave it on the board will start to turn green with oxidization. The only time use water soluble flux is when you have very oxidized parts and nothing else. View it as a last resort because cleaning the board with water and having to dry it can be a hassle. The moisture can seep into every nook and cranny and potentially cause problems later. If you do use water soluble, a rinse with isopropyl alcohol will remove the residual water away.

Rule #4 - Use the Right Tools

Now that we've discussed the correct solder and flux to use, let's move on to soldering tools you'll need and their purposes. We recognize that soldering is an expansive umbrella, covering a wide range of operations and applications that will cover most electronics. You actually do not need much more than a soldering iron to get started but to get high quality results repeatedly and keep your equipment properly, these are our recommendations.

Soldering Iron

The most important tool is of course the soldering iron. Irons come in a variety of wattages and sizes in the form of either a pen or gun.



Soldering guns work well for larger wires and surfaces but for PCB work, they are often imprecise and too big to fit into highly populated areas.



Soldering pens on the other hand have lower wattage and are made for precision work on printed circuit boards. They are the best for the smallest areas for precision work.



Basic AC Voltage Iron

When it comes to soldering pens, there is an abundance of inexpensive models that plug into an electrical outlet and heat up with no adjustment. These AC voltage irons work for basic soldering of wires but for circuit boards, you really need to know how hot the iron is.

Soldering Stations

Irons with temperature control will usually come as part of a system called a soldering station. The features and included accessories can vary greatly between models, but most will include a soldering iron, control unit, and holder for the iron and a sponge. The following are the typical categories of soldering stations you'll



Analog-Controlled Station

The next step above would be a control iron, which does have a control knob for temperature setting. These type work with a variety of wire and through-hole soldering



Digitally-Controlled Station

The best quality soldering irons will feature a controlled temperature that allows for precise control. This is important because certain types of wire and solder alloys will require specific temperature ranges to work and prevent damage. This allows you to conquer more soldering tasks.



Soldering & Rework Station

Soldering stations are not limited to just irons either! A rework station may include a combination of other soldering tools such as an air gun, desoldering gun, hot tweezers

Soldering Iron Stand

If you've ever seen or used one of those basic inexpensive soldering iron: probably been confused about where to place it when not in use. They typ come with any kind of decent holder other than a flimsy prop-up stand. Be soldering stations will have some kind of spring type or more advanced h



Prop-Up Stand



Spring-Type Holder



Advanced

Advanced iron holders often have many integrated components such as a tray, brass coil holder, solder wire spool holder, tip holder, or even attachn accommodate multiple soldering tools. These can be invaluable for keepin workspace organized and safe. We will go much further in-depth about iron options and wattage ratings in later sections.

It is **NEVER** a good idea to place the soldering iron flat on any surface wh because of the risk of burns and fire. Make sure to get into the habit of ret to its holder when not in use!

Soldering Iron Tip Types

An important consideration in choosing a soldering iron is the actual tips it has. In all, this is the part that will come in contact with your work. There are two types you will usually come across.

Regular Type



These standard tips are most common on modern irons. They are partially hollow with the heating element of the iron. In order to use them, the metal shield that protects the tip must be removed first. These tips are great for precision work, last a long time and are sometimes considered the best brands. Some models will use a set screw to hold the tip in place instead but they are often loose.



Cartridge Type

This second type is called a cartridge tip because it plugs directly into the body of the soldering iron. The heating element is actually built into the body of the cartridge, making it considerably longer. The main advantages of this design are faster heating, better economy, and the ability to heat more tips while working. Cartridge tips are also more durable and last longer than regular tips.

better heat recovery, and the ability to not swap tips while working. Solder with cartridge tips will usually come with a heat-resistant rubber pad for storage.



Soldering Iron Tip Shapes

Both regular and cartridge type soldering iron tips are available in a variety of shapes and sizes. Some have as many as 50 different tip shapes for a wide range of applications. These are the common groups you'll see when purchasing tips. If you're not aware, names and numbers can vary by manufacturer.



Conical Tips

The essential shape most people are familiar with. They come to a point like a cone or pencil. They are workhorse tips that are good for general work. Their narrow shape allows for the access to highly populated areas. Conical tips come in different lengths, as well as thicknesses to suit your needs.



Bevel Tips

These tips look like someone ground the conical tip or cut it off at an angle. They are either a flat shape or column shape. They're primarily used for desoldering and correcting solder bridges on a surface.



Chisel Tips

These tips look like flat head screwdriver tips with a flat point at the end of the tip. And like screwdrivers, they come in different sizes at hand. They are widely used for items with a large surface area to be soldered and SMD work.

Special Tips

R/RT Tips - These tips have an opening in the middle to accommodate SMD components, like the 0805 size and smaller.



RB Tips - These tips have a small bend of about 30° to the end of the tip. It is used for drag soldering and solder bridges.

H Tips - These tips have a smaller bend than the RB tips, about 25°, and are more of an oval shape. They are used in drag soldering and fixing soldering bridges.



J Tips – This tip style is much like a conical but with a hook at the tip. These are a secret weapon for SMD soldering small components.

K Tips - These look like the blade of a scalpel, or a hobby knife. It is used for narrow pitches, drag soldering, and fixing solder bridges.



1401/1403 - These tips are spatula/blade shaped for free soldering. They are used for soldering multiple pads at the same time, and reworking SMDs.

CM/BCM - These tips have a hollow bowl at the end of the tip to make drag soldering easier to solder the leads of surface-mount IC chips.

Tools for Cleaning

Wet Cellulose Sponge



The wet sponge is the most common method for tip cleaning. It is standard issue on almost every soldering station out there.

- ✓ Cost-effective
- ✓ Highly-efficient at cleaning flux acid
- ✓ Sponge can be cleaned for extended use
- ✗ Momentarily drops tip temperature
- ✗ Thermal-shock from water can shock the tip

Abrasive Brass Coils



This waterless method of cleaning uses abrasive coils to remove solder from the tip quickly without dropping temperature.

- ✓ Fairly inexpensive



- ✓ No risk of thermal-shock to the iron
- ✓ Indent on enclosure for resting iron (models)
- ✗ Doesn't clean as well as water
- ✗ Although soft, it can still shorten tip



Manual Desoldering Pump

If you've got a lot of solder to remove, the pump or "solder sucker" is a must. When the button is engaged, a vacuum is created. The heated, teflon tip can then be placed at the joint. When the button is pressed, it sucks the molten solder out. The design is semi self-cleaning but can get jammed and must be cleaned out before use.

Tools for Tinning



Tip Tinner

Tip Tinner is a compressed tablet that is a mixture of solder and oxide reducing compound. Used for safe cleaning and re-tinning of soldering iron tips. It is preferred over solder because it does not contain any harmful chemicals that can reduce the life of your tip and is safer. Tinning is discussed in-depth at rule #9.

Tools for Wire Stripping

One of the most crucial skills to master before soldering wires is cleanly stripping insulation. There are a few different methods you can use depending on your needs.

Utility or Hobby Knife



A simple but effective tool for stripping wire. Use the blade to score around the wire insulation, making sure to go deep enough. These also come in handy for removing solder and working with coax cable.

Finger Wire Stripper



A step up from the hobby knife but similar idea. The wire is inserted into the appropriate groove and allowed to be pulled around the insulation using your finger through the handle. These work great for larger shielded cables.

Manual Wire Stripper



The manual wire stripper is our favorite tool for a few reasons. It's cheap, it gives you a lot of control, and it works great! There are basically two versions that come across. Some have just open jaws with notches and others have several indents for specific wire gauges. If you know the wire gauge, the marked ones are better because you know it won't cut too deep. However, the open jaw version is more versatile.



type can handle most gauges as long as you're bite down on the insulation and twist around the the insulation still in the jaws, pull up to remove

Pro Tip: Wire strippers work a bit better for you when they have dulled a bit. The sharpness of a new pair can cut through the insulation too easily, leaving you broken conductors.



Automatic Wire Stripper

If you have to make a ton of wires and speed is a factor, these could be your best choice. Automatic strippers take the guess work out of it. It is also less fatigue on your hands and they are also thermal wire strippers that use heat to remove the insulation.

Other Helpful Tools



Needle-Nose Pliers

Needle-nose pliers come in handy for soldering component leads and placing parts where you need to go. Our favorite type are the ones with non-slip jaws for better grip. We will talk about that in Rule #12.

Flush Cutters



Once your parts are soldered in place, usually have to be snipped. This ensures they don't touch other metal surfaces and short out. A quality pair of flush cutters will allow you to reach where you need them. A must for zip tie



Helping Hands (Third Hand) or Vise

Many times, we wish we had another set of hands to hold components while soldering. The solder buddies usually have 2 or more alligator clips connected to a weighted base. Your circuit wires, and parts can then be held in the clips while soldering. Some will also have a magnifying glass to give you a better view of the workpiece during the soldering process. We highly recommend getting a third hand because it makes every job easier and safer. You can even fabricate one if you use cardboard or other rigid materials.



PRO TIP: Add heat shrink or electrical tape to the alligator clip ends to prevent damaging your wires, boards and parts.

Parts Bins



No matter what kind of project you're doing, you want to keep track of all your parts and components. We recommend having several plastic parts bins of varying sizes for organizing and storing components during disassembly and new builds. There are many different types of parts bins available as well for static-sensitive components.



components. Scrap pieces of cardboard come in handy for creating “templates” parts through it, especially keeping track of many cases, cardboard can make an excellent “buddy” to hold parts while soldering together.



Lighting

There's no use in trying to solder something if you can't see what you're working on! Having a good source of light on your workbench will be one of the best investments you ever made. The adjustable gooseneck and swivel are perfect for positioning exactly where you need light.



Inspection Visor or Microscope

Many techs will also use magnifying inspection visors with built-in lights or digital microscopes. These allow them to get right over the target area.



Digital Camera

During tear-down and assembly, you'll want to document everything. It's definitely your smartphone or digital camera. I recommend taking lots of pictures throughout the process. You'll be glad you did later. The



step, you'll be glad you did later! Tru

Rule #5 – Practice Soldering Safety

When it comes to soldering there are few safety concerns that must be addressed. First, working with temperatures of up to 840°F (449°C) introduces risk for burn. Second, electronic devices inherently present a risk of electrical shock. And the soldering process itself produces fumes that are hazardous to breathe in. However, though, as long as you know the risks, you can mitigate them by working



Fume Extractors (Smoke Absorbers)

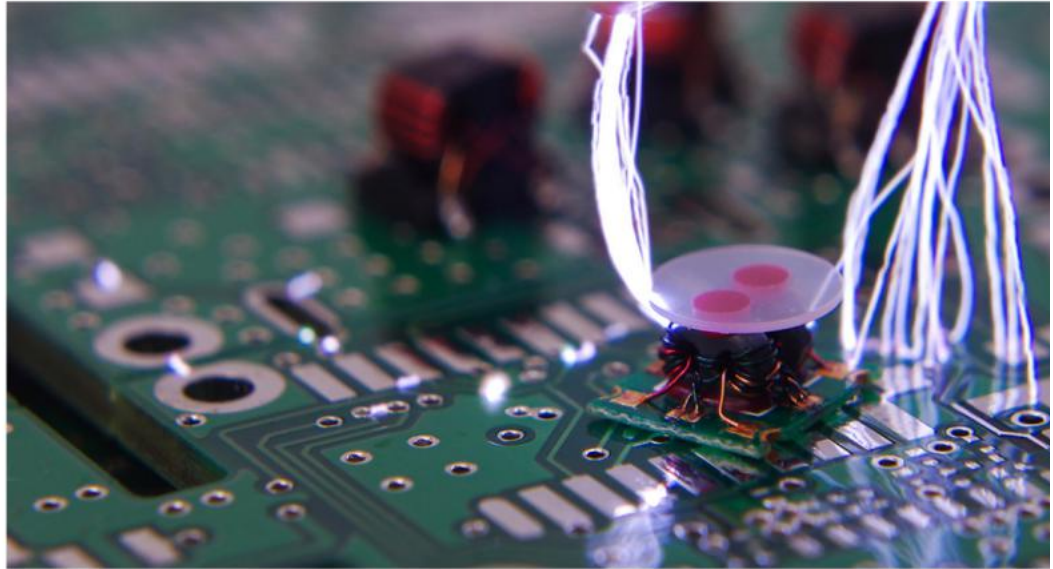
The number one safety precaution to take when soldering is doing so in a well-ventilated area. If you are soldering as next to an open window where air can circulate, that's fine. In any case, we recommend using a stand-alone fume extractor or one integrated into the iron stand. The fume extractor will pull the fumes through its carbon filter and vent them away from your face.

Soldering Mats



As part of your setup, we also recommend using a heat-resistant rubber mat to protect your work surface from any burns and scratches. Residue from molten solder, component leads, and chemicals can wreak havoc on your work surface. A nice soldering mat will stop all this from

table, so it's a great thing to have. It will keep your components from rolling into the back of the ground. There are also ESD safe mats that protect sensitive components from static charge that is naturally generated.



What is ESD?

Electrostatic Discharge or ESD is a surge of electricity from one object to another. This can occur when a higher charged object nears or makes contact with a lower charged object, thus creating a statically charged surge.

Friction can cause static electricity to build up in an object and transfer it to another object. Some electronics components are highly sensitive to ESD and are damaged easily by it, so using ESD safe tools and equipment will mitigate the risk.



WARNING: Risk of Electrical Shock



Finally, please be aware of the risk for lethal shock when working on electronic devices. Make sure power to the device is off and the power cable is physically unplugged from the outlet before opening anything. It is also important to drain any electrolytic capacitors before soldering because these can hold an electrical charge long after the device has been unplugged.



Leaded Solder Exposure

Please note that when using leaded solder alloys, the risk of lead exposure is not just through touch. Lead does NOT vaporize (fume) at normal soldering temperatures. The fumes created by soldering are actually caused by the flux in the wire coming off. Even though the smoke does NOT contain lead, it is still not good to breathe and should be avoided.

Gloves



Using leaded solder is like handling radioactive material. You should avoid contamination as much as possible and always wash your hands when done. Especially if you're actually going to handle the solder. I recommend wearing gloves when possible to avoid exposure of lead and other chemicals coming off the solder. It will also make clean up a bit quicker. One downside is that it may be difficult to work in precise operations. Whether you use gloves or not, stay cognizant of what you're touching and wash your hands after.

Protective Eyeglasses



The threat of getting something in your eyes is greater than you would think when soldering. The obvious reason for protective eyewear is to prevent fumes from getting in your eyes.



other dangers like accidental splashes
flying component leads, trimmed zip tie
insulation can cause some serious dan

Rule #6 – Understand the Art of Heat Transfer

Earlier we discussed methods for heat transfer but let's now take a look at factors that affect it when hand soldering. Start by taking a look at your project and visualizing the outcome you want to accomplish. Analyze the components and their size and makeup. Are they fragile or tough, plastic or metal, big or small? Do they have moving parts like a potentiometer or are they solid? These answers will guide your approach because they all affect heat transfer in one way or another.

The goal of soldering is two-fold. First, to get in and out as quickly as possible to prevent damage to components you're working with. Second, to make a proper mechanical and electrical connection at the joint.

Managing the Heat Cycle

To do this, you must be able to manage the "heat cycle". Which is simply how long the joint heats up, how hot it gets, and how long it stays at that temperature. This is important because heat along with pressure are the two main causes of damage to the PCB. Both can easily cause the copper pads and traces on the board to lift, leading to a more difficult and frustrating repair. However, one must also not be afraid to apply heat because it is crucial to a successfully soldered joint. Taking it away too soon, like using a paintbrush" with the iron can lead to cold solder joints where the connection is not hot enough for wetting to occur.

The soldering iron is not a paint brush, it must be held on the joint until a proper connection has been made.

The time you spend on a joint is referred to as the “dwell time” and it can be affected by a variety of factors. In the coming sections, we’re going to touch on everything that affects heat transfer from tip temperature to tip size. Understanding this will help you master the heat cycle and make the difference between a novice and professional solderer. I’ll be referring back to these concepts frequently because they influence basically all decisions of what tools and techniques to use while soldering.

Rule #7 - Use the Right Temperature

You may be thinking that tip temperature is the most critical factor for heat management but this is actually not the case! While it is important, it's only one piece of the management puzzle. The iron must be hot enough to melt the solder alloy you are using but not too hot as to damage the components and board. Always check the specifications of your solder to make sure. The right temperature then becomes a balance between heating the joint quickly and allowing enough dwell time for the solder to wet into the joint.

For general electronics soldering, somewhere in the range of 572-662°F (245-350°C) is a good starting point. This can vary based on the size of the components and the board makeup. For heating very large parts, you'll likely want to be in the upper end of the range. Conversely, if the component is smaller or very heat-sensitive, you'll want to be in the lower range. Some soldering stations will have preset functions that allow you to jump between saved temperature settings depending on the work you're doing.

Proper tip temperature is most critical for PCB work. As we said earlier, you need to know how hot your iron is getting to properly manage the heat cycle on the board. We highly recommend a soldering station with digitally controlled temperature for this type of work.



Heat Sinks

It may also be helpful to use a heat sink when working on large components. Alligator clips or forceps (shown) make good heat sinks that will hold the part as well as absorb the heat from the soldering process.



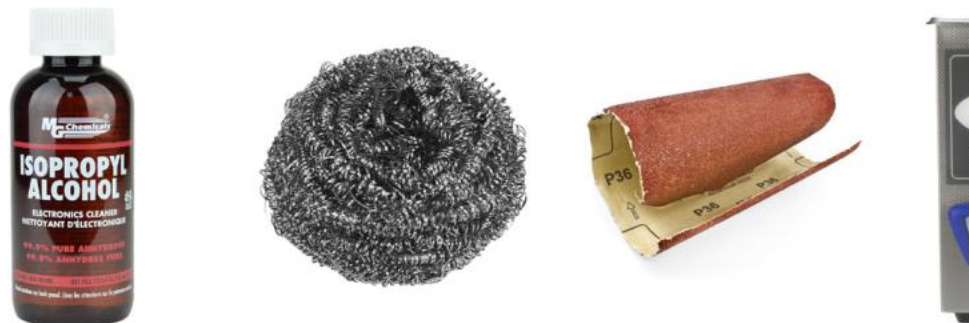
...because that will hold the part as you sink is added, the surface area that the is increased; therefore giving you a long

We don't recommend cranking the temperature up to the highest it will go (Approx. 896°F / 480°C) because the tip will oxidize very quickly. If not careful, you can ruin the tip in a matter of minutes.

Rule #8 - Keep Your Surfaces Clean

All surfaces involved in the soldering process must be free of contaminants before soldering. This means the surfaces of the work piece, components and the iron tip. Remember that even the thinnest layer of oxides can prevent solder from sticking and wetting properly. Similarly, when you've got a dirty or highly oxidized iron tip, it just not going to transfer heat effectively.

The level of filth present will dictate how much cleaning you'll need to do. With clean components, you can usually get by with just the flux-core in your solder and a well-maintained soldering iron. When reworking old or oxidized parts, you need to clean them the best you can before soldering. To clean any foreign material from component leads, wires, and solder pads, you can use a solvent like isopropyl alcohol, fine steel wool, fine sandpaper, or in some cases an ultrasonic cleaner if necessary.



If you're still having trouble soldering after pre-cleaning the surfaces, you can try a more aggressive flux like RA or Water Soluble. Just remember to clean the flux residue off after because it is more corrosive.

Keeping Your Iron Tips Clean

There are two ways to clean your iron tip and they are wiping on a wet sponge or plunging into brass coils. There are pros and cons to both but we recommend a hybrid approach for the best results and convenience. The semi-abrasive brass coils remove the bulk of the solder residue off without dropping tip temperature, while the wet sponge more effectively shocks away the acids from the flux.

How to Clean Using a Wet Sponge

1

Take a spray bottle filled with water and wet the entire sponge but don't drown it. An excess of water will drop the tip temperature too drastically, which will reduce the life of the tip because of the stress it's under to recover from the heat loss.



2

To check for proper dampness, push down on the center of the sponge with your finger. If you get a pool of water, it is too damp and the excess should be dumped out before continuing.

You should usually hear a "Pssh" sound when cleaning. If you don't, the iron may not be hot enough or the sponge not wet enough. A dry sponge will burn from the heat of the iron leaving black marks.



3

The best way to clean all sides of the tip is by making an "X" in two passes. First, drag the broad side of the iron across the sponge diagonally from the top of one side to the bottom of the other. Then make a half circle turn while keeping the same grip and drag across the sponge in the opposite direction to clean the other side of the iron tip.



Repeat if necessary until visibly clean and remember you don't want to be poking the sponge with the tip of the iron, the whole surface should be making contact.

PRO TIP: Contamination of solder and flux residue built up on the sponge will start to affect your cleaning and tip. Periodically, you should dump out any solids and use both sides of the sponge until they are dirty. They should then be laundered or replaced.

How to Clean Using Brass Coils

1

Plunge the hot soldering iron into the brass coils but not too deep because you will hit the bottom of the container and risk damaging the tip.



2

To take it up a notch, you can twist the iron with your fingers while cleaning to help get all sides. Try not to keep jabbing the same spot, move around to disperse the solder and ensure effective cleaning.

3

When the solder and flux build-up start affecting cleaning, flip over the coils and use the clean side to extend its life.

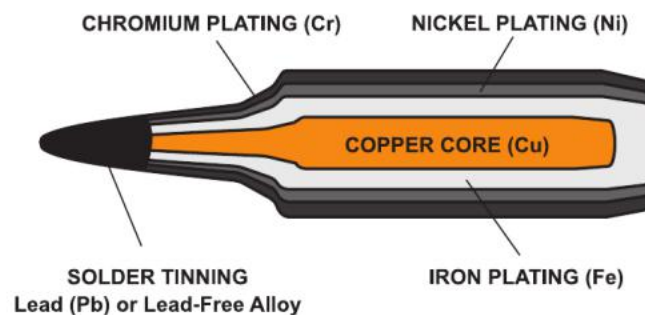
PRO TIP: When there's too much solder applied to your tip or you want to simply remove excess, you can flick it off into your sponge to remove quickly. Be careful of molten solder and wear safety protection.

Maximizing Tip Life

Please **DO NOT** use a file, scouring pad, or sandpaper to “clean” your tip: practice dates back to when soldering tips were simply bare copper and reoccasionally reshaped.



Modern tips are plated for extended life and performance, making it unnecessary to file. However, using a file is actually very damaging. New soldering tips are constructed of a copper core plated with iron, chromium, and nickel alloy for strength.



When you file the plating off, you dramatically reduce tip life by compromising the ability of the tip to melt solder and for solder to stick to it. Once you get through the plating, you create a hole in your tip and it will no longer work correctly.

Mechanical Force

Using the iron in an abrasive manner by applying force and pressure will ruin the tip. You shouldn't have to apply any more pressure than the weight of the joint; let gravity do the work here.

Rule #9 – Keep Your Tip Tinned

The only way to keep your tips working perfectly and maximize their lifespan is to keep them properly cleaned and tinned. Tip tinning is the practice of adding solder or Solder Tinner (solder-like mixture) to the tip for protection and to achieve optimal

The expression “tinning” comes from the fact that solder was sometimes called tin in the early days of soldering. All solder is made up of mostly tin with other metals and additives.

Pre-Tinning

Applying solder to the tip before soldering helps to jump start the heat transfer as the flux cleans the tip and gets the solder flowing before you even touch the components. It also comes in handy in situations where you need one hand free. If the heat is hot enough you can sometimes solder it just by pre-tinning the iron. Other times you can add a little bit of solder to “tack” a component in place to make it easier to move or to pin without it moving.

It is important to tin the tip before returning the iron to its holder as this will provide a protective coating on the tip. The fresh Solder or Tinner forms a gas tight seal that prevents oxidation caused by sitting in the open air is dramatically reduced.

Any solder residue that is left on the iron after coming off a joint should always be cleaned off because it includes other contaminants from the components. If the iron is smoking excessively in the holder that means there is a concern that there is still something on there that needs to be cleaned off. Again, flux acids will eat away at the iron if left on the tip.

the tip, reducing its life.

How to Tin Your Tip

When using your iron for the first time, you will want to perform a renewing tinning and cleaning until the tip has a nice coating of fresh solder built up solder easily. Oxidation can form over night as well, so still do this at the s day before your soldering session for best results.

1

Turn on the soldering iron and set it to around 608-662°F (320-350°C).



2

Clean the iron on a wet sponge or brass coils several times to remove any surface oxidation.



3

Add a layer of solder or Tip Tinner all around the tip to coat it evenly.



4

Clean the tip off on the sponge or brass coils to remove excess solder, leaving behind a thin layer.



5

Now try to tin the tip with flux cored solder to see if it will accept it. If it does, you are done and can begin your work. If not, repeat these steps until it does.



Rule #10 - Pay Attention to Surface Mass

What we mean by this is the size and surface area of the parts being sold of the iron tip itself. When choosing a soldering iron tip, you want to match work you're doing. The shape is in part up to your preference but also what the joint and provides the greatest surface area for heating. In general, the more efficient it will be because it is closer to the heating element and more evenly distributed. The simple physics here is that larger components longer to heat when using small tips and vice versa.

*Small Tip + Big Mass = Slow temperature rise
Big Tip + Small Mass = Fast temperature rise*

Most soldering irons will have interchangeable tips that can be quickly swapped replaced when worn out. There are two main types of tips which are the standard that sit on the heating element and the cartridge type that plug into the iron. Cartridge type tips actually have the heating element built into their long body. One advantage is that they can be changed very easily while working. Both standard and cartridge tips come in many different shapes and sizes, each with their own use or application. The most common are the pointy shapes known as "conical" tips. They are great all-around workhorses for general soldering use. When you've got large components or more surface area to heat "bevel tips" come in handy with them. Make the job easier and more efficient heat transfer.

Use the Contact Patch Advantage

The contact patch refers to the surface area between the iron tip and the work being soldered. If you only use the very tip top of the soldering iron to solder, you limit heat transfer. By using the broad side, you increase the surface area or "contact patch" and make the job easier and more efficient heat transfer.

resulting in superior heat transfer. This means you can get in and out fast and spend less time heating the joint.

In order to better understand this concept, try a dry run without heat so you can see the surface areas that touch while soldering. Another masterful way to increase heat transfer is by using solder to expand the linkage. When you add solder with the iron tip and the joint you are adding mass to both. Not to mention the solder is cleaning the surfaces, aiding in the heat transfer and allowing the solder to

Make Sure Your Iron is Powerful Enough

The job of every soldering iron is to generate and store heat. When you touch it to a mass such as a component or circuit board, it will start losing its heat to the mass you're trying to heat or the longer it sits there, the harder the iron has to recover the heat loss. This is known as the rate of recovery and the heat capacity of the iron is measured by its wattage rating. In order to last longer and heat without dropping temperature, more wattage is needed.

Iron Wattage Explained

Having a higher wattage means that the iron has a larger heating element "thermal mass" to draw from before the temperature starts dropping. In a worst-case scenario, a low-wattage iron could actually get stuck to the work piece from being drained of its heat, allowing the solder to solidify.

Generally speaking, a basic AC voltage iron of around 40-60W is ideal for most electronics work. Anything higher wattage on a non-digitally controlled iron will get too hot to handle and won't regulate accurately. When the temperature is regulated by a microprocessor with a feedback loop, higher wattage ratings become an asset. This is because the iron can maintain your set temperature no matter how big the surface area is. Where higher wattage simply means more heating power in reserve to use if needed. This opens up the possibility of using anything from 40 to even 100 Watts for electronics work.

Basic 60 Watt Iron



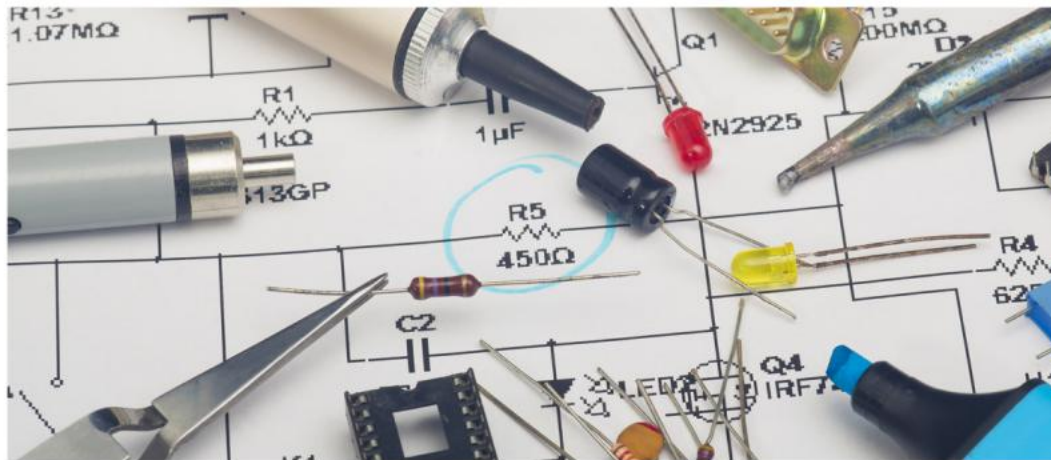
Digitally-Controlled





Rule #11 - Place Your Components Secure

Almost as important as soldering itself is how you install the components. Everything should be installed neatly, securely, and in the proper orientation. Components that are polarized with a defined positive and negative lead. If connected improperly, they can get damaged or worse blow up your circuit.



Axial Versus Radial Leads

In terms of through-hole devices (THD), there are two types of lead configurations: axial and radial. Axial leads run horizontally while radial leads run vertically.

General Component Installation Order



1. Sockets
(Note Orientation)

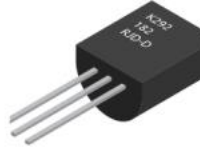
2. Resistors

3. Capacitors
< 1 Micro Farad

**4. Electrolytic
Capacitors**
(Note Orientation)



6. LEDs
(Note Orientation)



7. Transistors



8. Solid Wire



9. Stranded Wire

The Art of Lead Forming

Sometimes out of the bin or box, your components can have bent or even broken leads. When forming leads, it's nice to start with the leads as straight as possible. A favorite tool for this is long needle-nose pliers that have serrated jaws. An alternative version doesn't hurt either!

To straighten a bent lead, grab the lead so the jaws of the pliers are right next to the component body. Using your fingers, bend the lead back into shape. The pliers will serve as your guide to straightening. If there are kinks in the middle, move the pliers to right before the bend and again use the edge to straighten you can. Alternatively, you can cut that part off as long as there will be enough lead left to solder on to.

How to Form Component Legs

1

Dry fit the component over the holes of the board or the desired points of contact. Ideally equi-distant between the two holes or terminals. Pick one lead and note the point where you want the bend to occur.

2

Mark the spot by grabbing the lead with your pliers. Try to get it right before the point you want the bend to occur because you must account for the bend and the jaws of the pliers.



3

Using the hard edge of the pliers, bend the lead and flatten it against the edge to form a tight and professional bend.



4

Now line your newly bent lead up with the hole and make sure it looks good. Repeat the process on the other side using the holes or terminals as your guide to make it symmetrical.



5

If you find that the component is too big to fit into the space you can get more creative with your lead forming. Here we put three bends using the jaws as a measurement device to make it fit properly.



6

When done correctly the component should be able to slip right in without any fussing and sit flat on the board. The exception to this is leaving some height to allow for better heat dissipation.



7

To keep the component from falling out when you flip the board over to solder it. Bend them in opposite directions at a 45-degree angle.



8

For heat sensitive components like LEDs and diodes you'll want to add a heat sink like a small metal clip or forceps to absorb some of the extra heat.



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Rule #11 - Place Your Components Securely

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Tacking

To make it easier for rework (removing the part), you may want to leave the leads straight instead. A good way to do this is to hold the component in place with a pair of tweezers and use a pre-tinned iron tip to Tack the component. The idea is not to make a permanent solder connection, you're just trying to keep it in place temporarily. With it tacked in place, you can go solder the opposite side properly and then re-solder the tacked side.

Wrapping

Another way to keep leads in place on various through-hole terminals is to wrap them around the terminal. This creates a much more robust mechanical connection and it will be much harder to desolder later if needed. You might have to cut it to clear all the solder out without damaging the components. We recommend using this method only if you know it's staying there for a long time or there's no other way to keep it stay in place while you solder.

How to Prepare IC Chips



When IC chips come fresh out of the package, they are often bent at a specific pitch or angle and when you try to insert them into the holes or socket, it will likely not fit.

To correct this, all you need is a flat hard surface and a pair of tweezers. Hold the plastic body of the chip and place it on your hard surface.

Now carefully roll the chip to straighten the pins.



body of the chip and hard surface. Do the same side and then the chip should fit into the holes n

When the pins on a chip or chip socket become be very difficult to straighten without breaking th try using your fingers or pliers to do this as desc

Rule #12 – Add Solder and Heat Simultaneously

Now comes the time to finally solder our first connection! Many guides teach in such a way that is **NOT** conducive to the fastest heat transfer possible. They tell you to apply the iron at the joint and hold for 1-2 seconds. Then add solder at the opposite end, making sure to not touch the iron, and when the solder melts, you know the joint has reached temperature. The problem with this approach is that it takes too long to heat the joint, so you run a greater risk of damage due to heat. Instead, we recommend adding the solder and heat at the same time, which starts the heat transfer process.

How to Solder Through-Hole Components

1

Turn on the soldering iron and set it between 572-662°F (300-350°C). Turn on your fume extractor if you have one. Assemble all your parts on the bench.

2

When your iron gets up to temperature clean and tin it. Remember to always tin your tip before and after soldering. If the tip remains dry without solder during storage, you will greatly reduce the life of the tip.



3

Take up the solder spool about 2-3 inches from the end. This gives you enough wire to work with without getting burnt and allows for better control over it.



4

Next, position the solder wire right on the joint where the component lead or leads meet the pad or terminal. The end of the solder wire should not extend too far past the joint. You don't want to melt the wire in the middle and create waste. The idea is to feed the wire into the joint.



5

Now bring your iron in and press down right on top of the solder and connection. In this fluid action, you are effectively tinning the iron tip, starting heat transfer to the joint, and making the heat transfer quicker by increasing the contact patch between the iron and the joint with the solder wire.



6

Add more solder as needed to the opposite side of the joint to fill it in. Then as soon as you have enough, take away the wire and wait 1-2 seconds to make sure all the solder has been completely melted and wetted to the joint. If you leave the solder wire on the joint and take the heat away it will get stuck!



7

Remove heat and wait for the solder to cool and solidify. Please refrain from blowing on the joint to speed up this process because it can interrupt the



wetting action and create a cold solder joint.



8

Finally, clean the iron, tin it with solder or Tip Tinner, and return to its holder.



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Rule #12 - Add Solder and Heat Simultaneously

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How to Solder Wires

Soldering wires is a great place to start with soldering because it is much easier than circuit boards. You can spend a bit longer heating wires than PCBs but it is still a danger. The main concern is melting the insulation because it could expose the bare wires in your circuit. This presents a shock hazard and possibility of shorts in your device. Additionally, melted plastic doesn't smell very good and is harmful to inhale!

The world of wires gets quite vast when you start to look at different colors and cables that can be created with them. There's too many types of connections over in a general soldering guide so we will focus on the skills that will be used in applications. Then we will show how to do some specific methods for soldering wires together. All of which use similar soldering techniques. What differs is the connection made by twisting or wrapping the wires together.

Solid and Stranded Wire

The two most common types of wires found in electronics are solid and stranded wire. Solid wire has a single conductor whereas stranded has many smaller conductors twisted up a single wire. Stranded wire is more flexible than solid wire but the individual strands are easier to break. There is also braided wire, which is tightly laced strands primarily for shielding in long runs of cable.





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Rule #12 - Add Solder and Heat Simultaneously

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Wire Gauge

The size of wire is measured by its gauge, which refers to the diameter including insulation. These numbers are published by the American Wire Gauge (AWG) system works and it runs in reverse. The higher the number, the smaller the wire and vice versa. Larger wire gauges can handle more current.



Heat Shrink Tubing

When making a wire repair, the best way to cover the soldered area is with heat shrink tubing. This durable plastic tubing can be cut to any size needed. When heated, it shrinks down to protect and insulate the joint from moisture, air, and contact with other wires. It looks much more professional than electrical tape and offers better protection. It can be removed easily without leaving behind any sticky residues.

Heat shrink is commonly activated with a hot air gun but you can also use a lighter if you do not have a heat gun. If using a lighter, keep the tip of the flame (hot part) away from the tubing, use the blue base of the flame instead and you will avoid discoloration, or burn marks. The very tip of the flame will very quickly burn the tubing and heat shrink and compromise your joint.



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Rule #12 - Add Solder and Heat Simultaneously

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Wire Stripping



Using your wire strippers of choice, bite down on lightly to grip the insulation. Close down on the wire to slightly pierce the insulation. This will come with for you to get a feel for it.

It will likely pierce the bottom of the wire first and the idea is to cut through the insulation all the way

Score the wire by twisting the wire strippers around jaws still locked on the insulation, squeeze a little to remove the insulation cleanly.



If you are having trouble, you might be trying to remove much at once so in this case strip a smaller piece and finish it.

Be careful not to break any of the conductors inside you do, you should cut it off and try again.

Pre-Tinning Wires

Just as tinning your tip helps with heat transfer, pre-tinning wires before soldering help speed up the soldering process by cutting down on dwell time. Pre-tinning is done with a solder pot for higher production runs or with an iron and solder. In the case of stranded wires, it also keeps them together if you need to insert it



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Rule #12 - Add Solder and Heat Simultaneously

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Strain Reliefs

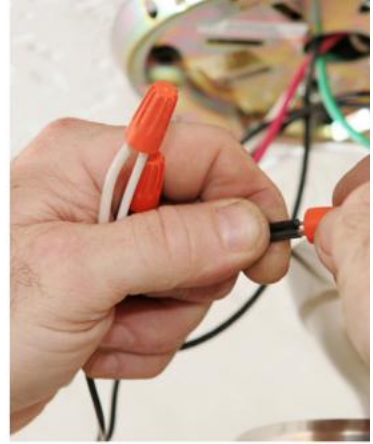
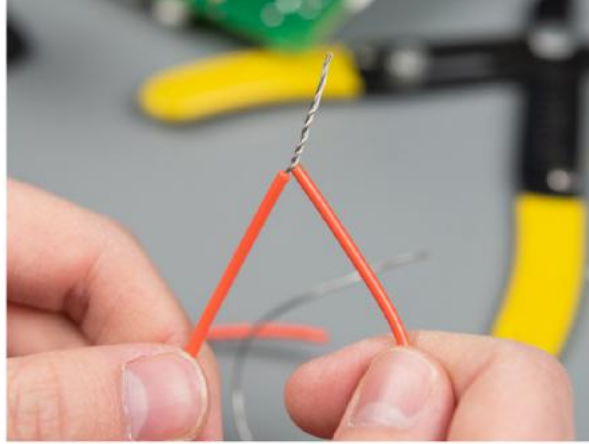
Wires and cables are usually subject to a lot of abuse from being plugged unplugged and pulled on. In order to reduce these weak points in wires, strain reliefs are used. There are many different kinds of strain reliefs you will come across. Equipment that has a hardwired power cord will always have a chassis strain relief to prevent anything from being disconnected and shorting out within the unit.



Rat-Tail or Twist Splice

The rat-tail splice, also called a twist splice or pig-tail splice is done by simply joining two or more bare wires together. It is used frequently in home electrical work but is not common in electronics because it is not very reliable. It is best used for temporary connections that may have to be changed in the near future. Electricians often use the wires together and secure them with a wire nut in receptacles.





How to Make a J-Hook Connection

When working with solid core wire, one of the easiest ways to connect two wires is interlocking J-hooks.

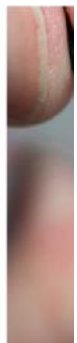
1

Strip the wire insulation equally on both wires. With cloth covered wire all you need to do is pull back on the insulation to reveal the conductor. Otherwise appropriate wire strippers are needed.



2

Using a pair of needle-nose pliers, come down a quarter of the way on the exposed wire and bend the wire around to form a "J" shape. Repeat step on second wire.



3

Cut a piece of heat shrink tubing that will cover the exposed wires and a bit of insulation on each side. Slide the tubing down one of the wires for later.



4

Bring the two wires together by hooking the ends on each other.



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Rule #12 - Add Solder and Heat Simultaneously

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5

Press the ends of the wire down with your fingers to pliers to form a solid mechanical connection.



6

Solder the connection. Use the broad side of the iron to heat up the joint. Apply solder at the same time to speed up heat transfer and fill joint.



7

Slide the heat shrink over the newly soldered connection so it is completely covered.



8

Using a lighter or heat gun, shrink the tubing down on the connection.



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Rule #12 - Add Solder and Heat Simultaneously

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Lineman's Knot or Western Union Splice

The Lineman's Knot is a special wire repair that creates such a robust mechanical connection that it cannot be pulled apart. The story goes that in the early days of the telegraph, people needed a way of repairing transmission lines that were high above the ground. In these locations where there is nothing around and no way to get up there, they needed a way of actually getting phone wire connected and back in service in a way that would not fall apart. The lineman's knot has been integrated into electronic repair for its strength. Which is made even greater by soldering and protecting them with heat shrink tubing.

1

Strip about an inch of wire insulation on both wires to be connected.



2

Dry fit your heat shrink tubing and cut the appropriate length to cover the entire repair. Slide heat shrink tubing onto one end of the wire for later. Keep away from heat until ready to shrink.



3

Twist the strands of the wires up with your fingers.



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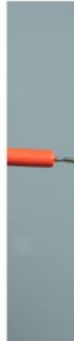
Rule #12 - Add Solder and Heat Simultaneously

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4

Come up from insulation about a 1/3 of the way and put bend in both wires. Put the bent wires together and bend them back on themselves

You should get a couple of wraps by wrapping them both in opposite directions.



5

Now you're ready to solder the wires. You can use a flux core solder only or coat the wires with a rosin flux paste to make it easy and solid.



6

Slide the heat shrink over the repaired area and make sure it covers completely. Use a heat gun or lighter to shrink the tubing down on the wires. Use the base of the flame to avoid damaging anything.





Rule #13 – Inspect and Evaluate the Joint



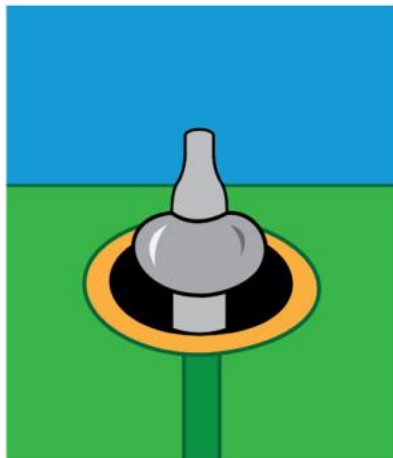
The Ideal Solder Joint

You should now have a perfectly formed joint with the solder vacuumed (sucked) into a cone shape on the component lead. The finished joint should be bright chrome in appearance if a leaded alloy was used. For lead-free, it will look more like a dull appearance opposed to shiny.

Common Soldering Errors

If your joint did not come out as expected, don't worry you can always try again. Sometimes a joint can look ugly but still be a fine connection, other times it is a bad connection and should be fixed. Let's go over some common soldering errors.

Not Enough Heat



Cold Solder Joint / Dry Solder Joint

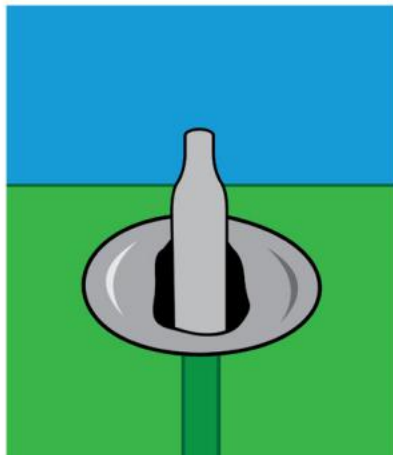
- The solder did not get hot enough to and for proper wetting to occur. This can be the component pin or lead, on the pad or both.

Appearance: Rough surface with possible voids

Insufficient Wetting on Pin or Lead

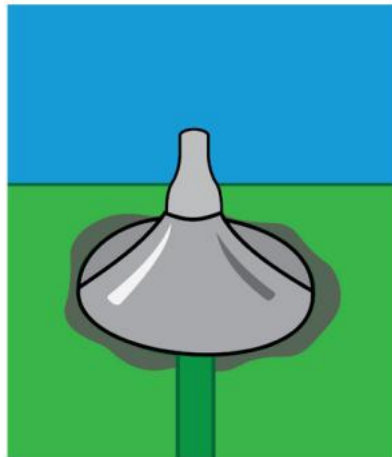
Insufficient Wetting on Pad or Terminal

Insufficient Wetting on Both



How to Fix: Heat the joint longer or turn up the temperature. Add more flux if needed and do not move the component.

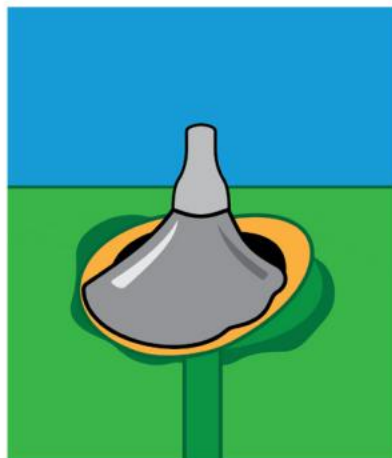
Too Much Heat



Overheated Solder Joint

The most common result of overheating is discoloration and burn marks on the circuit wires, the insulation can recede backwards. If the jacket looks very shiny, this is a sign the wire got too hot.

Crack due to vibration, liquid solder has



Lifted Pad

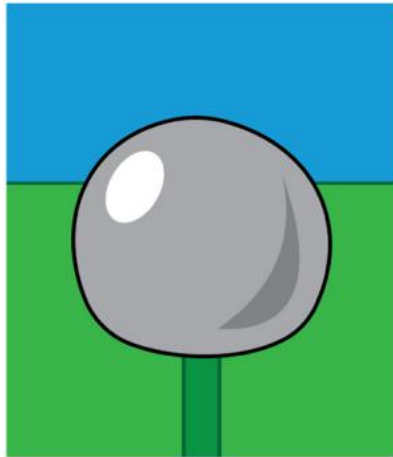
The worst-case scenario when working on a circuit board is a lifted pad. This is where the pad is so hot that it lifted right off the board. This is a problem to fix and you might end up having to re-solder the proper connection again. When done incorrectly, it is unprofessional and is not as reliable. It is outside the scope of this guide. Easiest fix would be to replace the wire.

Balance of time and temperature, can cause damage to components and board.

How to Avoid Overheating

- Don't apply pressure to the board or parts when soldering.
- Pay attention to the heat cycle, get in and out quickly.
- Add more flux to the joint or pre-tin the tip to speed up heat transfer

Too Much Solder

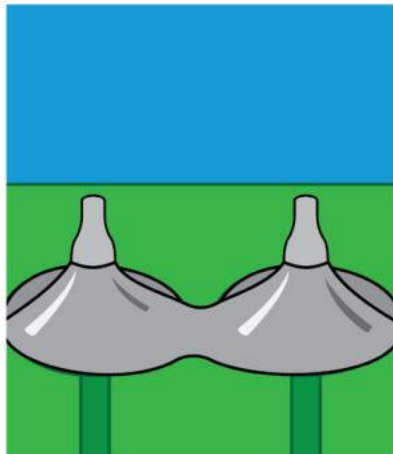


Solder Blob

When an excess of solder is fed into the joint, you get a build-up of solder on the joint that tapers down into a cone shape simply because of too much material and so little space.

Solder blobs also make it difficult to correct the solder actually wetted down into the joint.

To fix this, use a wick or pump to remove the excess solder. Alternatively, you may be able to catch the excess on your iron tip which you then wiped off on brass or wet sponge.



Solder Bridge

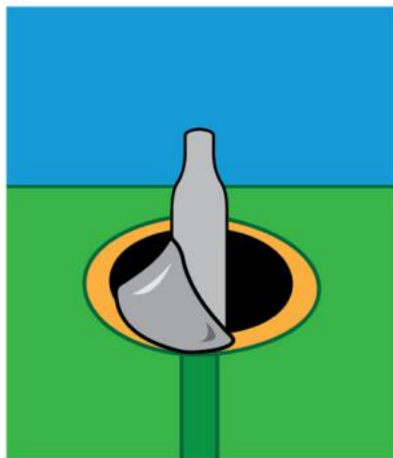
Another common soldering error due to too much solder is the solder bridge. This is where solder has accidentally spread across multiple pins, connecting them electrically. A solder bridge can cause a dangerous short and ruin your project.

Shorts can also be caused by untrimmed leads.

leads so make sure they are neatly cut reassembling.

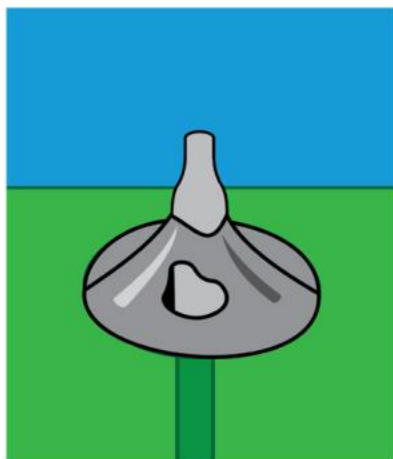
Sometimes when solder doesn't want to stick to one side of a plated thru can keep adding solder but it flows to the other side forming a solder blob you would need to clean the suspect side better and try adding more flux

Not Enough Solder



Tacked Joint

Component was tacked to keep it in place, but the operator forgot to solder a proper joint.

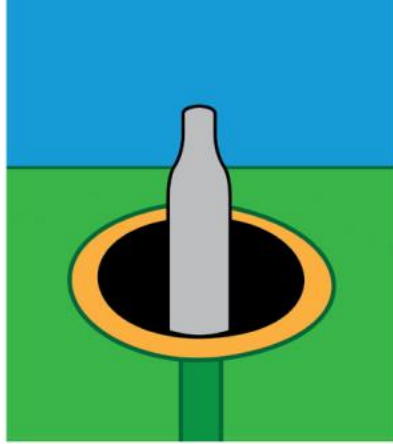


Solder Tunnel

Visible hole or gap in the solder joint.



Missed Joint

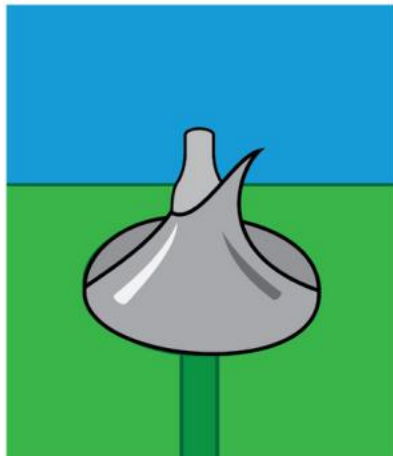


Missed Joint

The connection was never soldered during the manufacturing process.

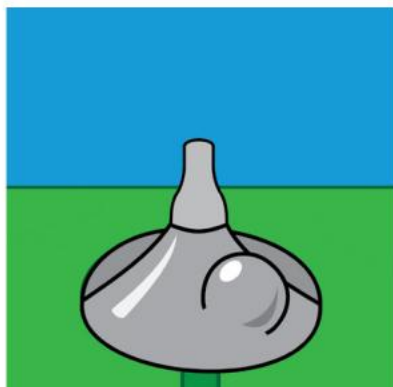
Moved Component

Disturbed Joint - If the component moves for any reason during the soldering process it will compromise the reliability of the joint. Components should be stationary and secured (Rule #11) when heating and especially when cooling.



Solder Spike

The iron was withdrawn too slowly causing a projection from the solder joint.



Solder Ball

The iron was withdrawn too fast or the iron was twisted.



Rule #14 - Desolder If Necessary

If you've found that your solder joint is not quite up to par, you may need to add some solder to try again. Also, if you accidentally installed the wrong part or the wrong way of your components, you will have to desolder. There are three ways you can remove solder which we will now cover.

The Manual Desoldering Pump

The manual desoldering pump is an excellent and cost-effective solution to remove a lot of solder at once. Using your non-dominant hand, grip the pump with your thumb, ring, and pinky fingers just below the trigger button.

Your index finger should sit right above resting over the button and your thumb (to depress the plunger) This way you can operate the pump with one hand and your other free for your iron.

Before heating the joint, be sure that the desoldering pump is not clogged by running it a few times. Be aware that dry solder remnants may splatter everywhere so direct it over a trash can or similar. If you hold the plunger down you should see the solder come out from the nylon tip. If the suction doesn't seem right, open the barrel and remove any solder remnants in there.

The desoldering pump can generate static charge and should not be used near sensitive components like CMOS and MOSFET chips.

Put the pump aside but close for now and locate the component to be desoldered. For through-hole devices it sometimes helps to apply pressure with one finger while using the pump.

component and feel for it on the other side to locate the pins. You could use a continuity tester on your multi-meter to help find the part. Mark the solder sharpie so you are absolutely sure before desoldering.

The goal with desoldering is to get the solder in the joint molten quickly as possible so you can suck it out without damaging any

How to Use a Desoldering Pump

1

Pre-tin your tip with a decent amount of solder. Maybe more than you would normally add because it will help the joint melt quicker and the solder sucker should still be able to get all of it out.



2

With the solder on your iron tip, pick up the pump and make sure it's loaded and ready.

Start heating one side of the joint with the broad side of your iron tip and wait for the solder to melt completely. If it doesn't melt within a second or two, remove heat and try again with more solder or an externally applied flux to speed up the process.



3

As soon as you see the solder getting molten all around the joint, bring in the pump and place the tip over the joint on the opposite side. The tip is heat-resistant plastic so it shouldn't contaminate the joint or your iron.

You want to have the pump tip right on top of the joint the best you can with the smallest gap possible for best results. If there just isn't enough room you can remove the iron and put it right over the center as long



as you're quick about it.

4

Press the trigger to suck the solder right out of the hole! If all went according to plan the component lead should be loose and the hole completely open.



More Desoldering Pump Tips

- If it didn't quite clean the hole wait a minute before trying again or move to another joint before coming back to it.
- If the part is temperature-sensitive, add a heat sink like forceps, plier clip to dissipate that extra heat and provide an easy way to pull the component out.
- Desolder one side of the part at a time and never try to yank the part out. You will likely damage the circuit board pad or trace making for a much more difficult and frustrating repair. If you hear a clinking noise while trying to pull the part out, stop and make sure the joint has melted completely before continuing.
- If the holes have been adequately cleaned, the part will just fall out or be easily pulled out. Sometimes mild wiggling can help get it loose but be careful not to damage the board.



Sometimes component leads can get stuck by a little solder that was left behind. If you can't seem to get the hole clean with any desoldering methods you can heat the joint and try pulling the part out instead.

To do this, pre-tin the tip with a decent amount of solder. To the joint, add more solder if needed to get it totally molten.



Once melted, wiggle and pull the component out of the hole with pliers or forceps. You can do this same technique when inserting the new component as well but just be careful not to damage the board.



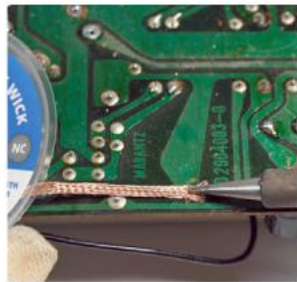
its heat long enough to wet properly or touch it up position.

In a last ditch effort, you can simply cut the part out and then either de-solder after or if the hole is big enough, insert the new part by just heating it up at the old lead in there.

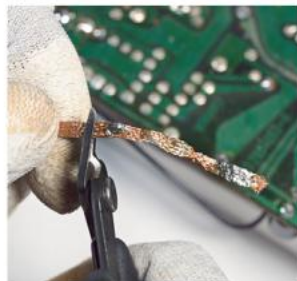
How to Use a Desoldering Wick



STEP 1 - Position a clean piece of the wick over the solder joint to be removed. If re-working old parts, it may help to first add some fresh solder to promote optimal heat transfer. Do not use too much though because you'll be wasting the



STEP 2 - Use the soldering iron tip to heat the wick and the solder joint simultaneously. When the solder melts, it will be captured by the joint and absorbed into the copper braid. A temperature of 662°F is typically a good starting point.



STEP 3 - Once the wick becomes saturated with solder, remove it from the heat and wick simultaneously. If the joint is not fully cleared, use a portion of the wick and repeat as needed.

Additional Desoldering Considerations



When you need to remove a large quantity of solder, desoldering guns are excellent for clearing through holes and efficiently.

Solder removal gets trickier as component sizes get smaller. Surface-mount parts with leads that are hidden under other components or in closely populated areas will need special treatment. However,



have space to get a soldering iron around all the I
damaging anything than you could try something
Chip removal alloy and tacky flux. The low-tempe
keeps the solder in a molten state long enough to
entire chip and remove it with tweezers or vacuur

When a soldering iron is not feasible, a hot air rev
and solder paste is your best bet. Hot air guns als
nozzles tips available that are designed for exact
package types and sizes.

Rule #15 - Clean Up Your Mess

We've made it to the last step, clean up! You can clean as you go or wait until the end of your project. The first thing you should do after verifying your solder joints is to trim any long component leads sticking out.

Trim Your Leads

Trim any protruding leads with flush cutters so you have just a little bit visible above the solder cone. Make sure there aren't any solder remnants left in your device cavity, these could cause a short later. Hold the lead or cup your hand around it so it doesn't fall in. You can also get pliers with a lead retainer that will catch the lead after cutting.

Clean Flux Residues

Depending on the type of flux used you may want to clean residue left over. No-clean and Rosin-based fluxes generally do not need to be cleaned off. However, any inorganic fluxes with aggressive acids will require cleaning to prevent corrosion. We recommend using either isopropyl alcohol or lacquer thinner. The board should look squeaky clean. Alternatively, you could use an Ultrasonic Cleaner. Make sure all the parts on the board are sealed from moisture. There are special cleaners for use with circuit boards called Saponifiers.

Final Thoughts

Thank you for reading our electronics soldering guide. In these 15 steps, we covered the fundamentals and reasons for soldering. As well as how to identify components, soldering methods and choose the right tools for the job. These foundational skills will help you get into any soldering job with confidence that a favorable outcome is possible.

Next, we discussed the art of heat transfer and the importance of managing temperatures, keeping all surfaces clean, tinning your tip, and paying attention to surface mass. The balance between heat, surface mass, and cleanliness is the key to successful solder joints every single time.

We then learned how to place components securely and maximize heat transfer by using the broad side of the iron. Applying the heat with solder simultaneously allows for a more efficient heat transfer. Which reduces the risk of damage by overheating.

Finally, we showed you how to spot an ideal soldering joint and prevent common soldering errors. Knowing what to look for is a crucial skill to ensure every joint is perfectly formed before moving on. Remember, if something goes wrong, don't be afraid to desolder and try again! Once the soldering is completed, all that's left is to test and assemble the project.

Congratulations, you are now a certified SRA Solder Expert!

If you have further questions about soldering or the products mentioned in this guide, please feel free to reach out to us through email, phone, or social! You can also find our Amazon list for our most popular items at the link below. Also, be sure to check out our Resource Center blog and YouTube channel for more great content. Happy soldering!





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